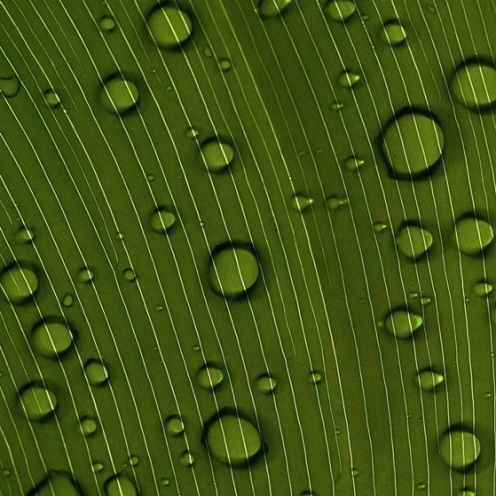
Weird Life Could Life Be Based on Another Liquid?

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By Guest Writer <http://www.reasons.org/articles/weird-life-could-life-be-based-on-another-liquid>



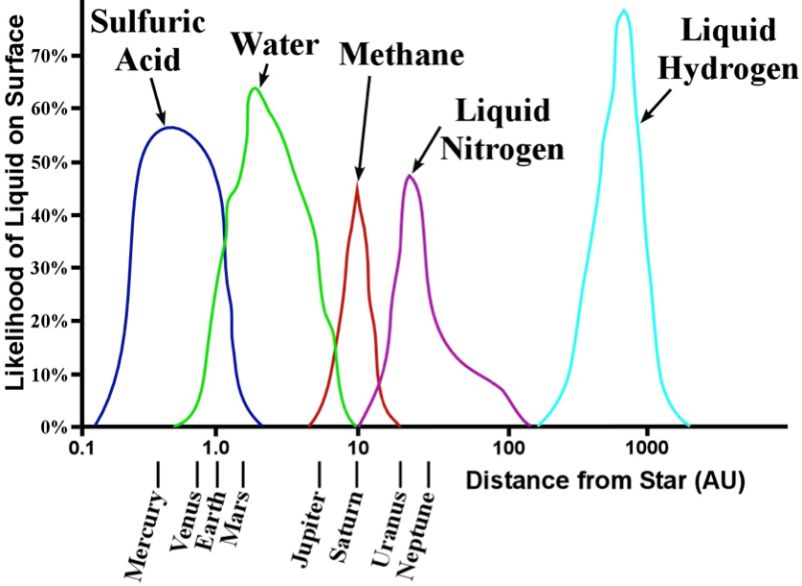
The science-fiction television show *Babylon 5* featured a [giant space station](https://en.wikipedia.org/wiki/Babylon_5_(space_station)) where humans and aliens could meet in peace. The eponymous station’s design had to be able to support alien races whose natural habitat was drastically different from humans’. Some of the aliens breathed gases other than oxygen, others needed hotter or colder temperatures, and still others required higher or lower gravity. This feature of *Babylon 5* reflects our understanding that planets outside our solar system exhibit a wide variety of different environmental conditions. One possibility the show never explicitly explored is exotic aliens with bodies dependent on a liquid other than water.

While the alien races of *Babylon 5* were fictional, many people believe that extraterrestrial beings do exist and that some of these might be truly “weird.” In this context, weird life refers to hypothetical organisms utilizing biochemistries that are radically different from anything known. One form of weird life could be based on the element silicon rather than carbon, as we discussed in [a previous article](http://www.reasons.org/articles/weird-life-could-life-be-based-on-silicon). Weird life could also use a liquid other than water inside its cells. Scientists generally agree that all of the molecules and biochemical reactions needed for any conceivable organism must take place in a liquid environment. This liquid medium is referred to as a life solvent (see [here](http://www.reasons.org/articles/weird-life-must-life-use-water-as-its-solvent) for details).

For all Earth life, the liquid medium inside cells is water. The problem is that few planets are likely to have the just-right environmental conditions to allow large oceans of liquid water to exist for cosmic periods of time; therefore, few habitats would be suitable for water-based life. Most planets would be either too hot or too cold for liquid water as we observe in our own solar system. So, the first question to ask is whether other planets might support other compounds in a liquid state.

**Cosmic Abundance of Liquids**

[Theoretical studies by William Bains](http://www.ifa.hawaii.edu/~meech/a281/handouts/Baines_astrobio04.pdf) suggest that many planets should be able to support at least one liquid on or beneath the surface.1 His model attempts to describe conditions in an “average” solar system. Based on these conditions, Bains estimates the probability of finding specific liquids as a function of the planet’s distance from its parent star (see figure 1).2   
For scale, our own solar system will be used as a point of reference. Planets located close to their stars (like Mercury and Venus) are hot, but sulfuric acid (H2SO4) could be present because it has a much higher boiling point (337°C/639°F) than water. Planets located a bit farther out (similar to Earth and Mars) would be cooler and might support liquid water (H2O) or ammonia (NH3) or both. Moving still farther out (corresponding to Jupiter, Saturn, and their moons), temperatures are low enough that methane (CH4) will liquefy and could form pools or lakes. Finally, at the outer edges of the solar system (near Uranus and Neptune), conditions are likely to be so cold that only liquid nitrogen (N2) might be present.

  
***Figure 1: William Bains’ predictions for the probability of finding specific naturally occurring solvents in a liquid state on a planet in a hypothetical “average” solar system as a function of distance.****The locations of the planets in our solar system are shown for reference. Image credit: John Millam*

Observations of various naturally occurring liquids present in our own solar system lend general support to Bains’ model. While he might be correct in predicting the commonality of liquids in other solar systems, the question remains as to whether any of these fluids are actually capable of supporting life chemistry.

**Evaluating Possible Life Solvents**

In addition to the specific compounds studied by Bains, astrobiologists have proposed a large number of other possible life solvents.3 In order to assess the feasibility of each candidate, chemists have identified eight desirable properties of a life solvent: (1) naturally abundant; (2) a good solvent; (3) a large range of liquidity; (4) the ability to encapsulate; (5) large dielectric constant; (6) good thermal moderator; (7) low viscosity; and (8) high surface tension. Based on these properties and a variety of other chemical factors, chemists are able to assess a substance’s potential to serve as a life solvent. The conclusions presented here are summarized from our [full paper](http://www.godandscience.org/evolution/non-carbon_life.html) on this subject.

* **Ammonia (NH3)** – Ammonia is the most popular suggested alternative life solvent because it is both cosmically abundant and shares many of water’s positive qualities (although at lower temperatures). (We will provide a detailed report on ammonia in a future article.)
* **Hydrogen Fluoride (HF)** – Hydrogen fluoride is an intriguing candidate because it has many strong water-like properties. The problem is that it is very rare (because the element fluorine is [at least 1,000 times less abundant](http://en.wikipedia.org/wiki/Abundance_of_the_chemical_elements) than carbon, nitrogen, or oxygen in the universe).
* **Sulfuric Acid (H2SO4)** – Sulfuric acid is the best solvent candidate for hot planets like Venus, because of its high boiling point. One major problem is that it would be highly acidic (similar to battery acid).
* **Hydrogen Cyanide (HCN)** – Hydrogen cyanide is an excellent solvent, but it reacts readily with water and also tends to polymerize, so it is unlikely to be found in significant quantities on planets.
* **Formamide (HCONH2)** – Formamide is a simple organic molecule with several interesting properties, but it is vulnerable to reacting with water and so would require a dry environment.
* **Methane (CH4)** – Methane is of great interest to astrobiologists because of its widespread presence on the surface of Saturn’s moon Titan. Its chief difficulty is that because it is nonpolar, it poorly dissolves salts, ions, and most polar molecules. Second, it requires very low temperatures in order to be a liquid, which would slow down or stop possible metabolic reactions.
* **Nitrogen (N2)** – Molecular nitrogen is abundant in the universe but is a poor solvent.  And it requires far lower temperatures than even methane, which means that biochemical reactions would be exceptionally difficult.

**Conclusion**

Despite the variety of candidates, no clear alternative to water as a life solvent exists. Many of the possibilities can be rejected because they will not be present on planets in a liquid state in sufficient quantities. Others are a poor choice for life solvents because they do not possess all eight key chemical properties listed above. Of all the choices, ammonia is clearly the most promising alternative to water; we will explore it in detail in a future article.

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Guest Writer

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